A Concept for a Joint NASA/ESA Mission for In Situ Exploration of an Ice Giant Planet

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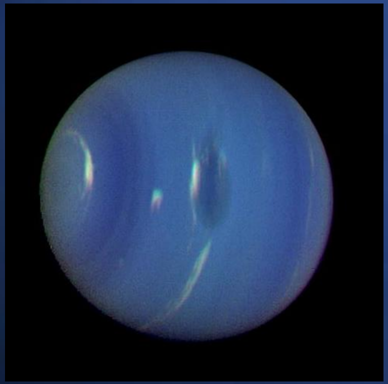
Jet Propulsion Laboratory
California Institute of Technology

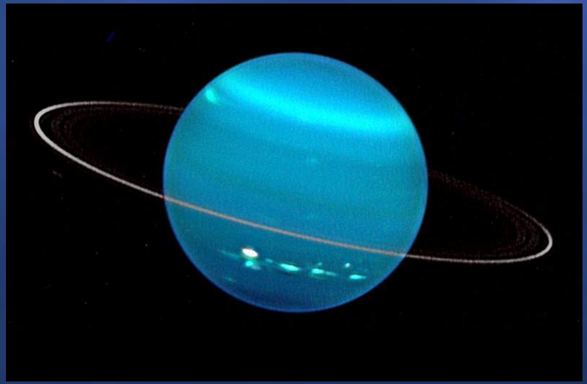
Science Justification for Outer Planet Entry Probes

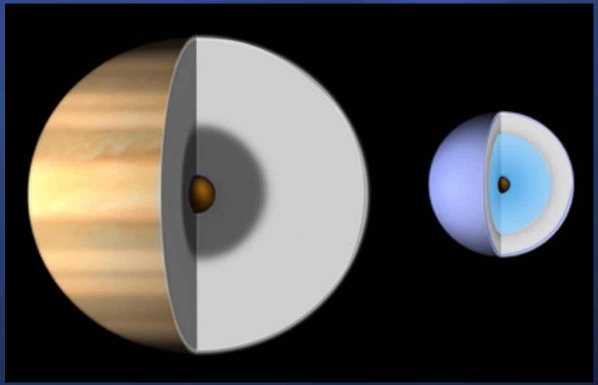
***Comparative planetology** of <u>well-mixed atmospheres</u> of the outer planets is key to the origin and evolution of the Solar System, and, by extension, extrasolar systems.*

Atreya, S. K. et al., "Multiprobe exploration of the giant planets – Shallow probes", Proceedings of the 3rd International Planetary Probes Workshop, Anavyssos, Greece, 2005.

For all the capabilities of remote sensing, only *in situ* exploration by descent probe(s) can completely reveal the secrets of the deep, well-mixed atmosphere containing pristine materials from the epoch and location of ice giant formation.

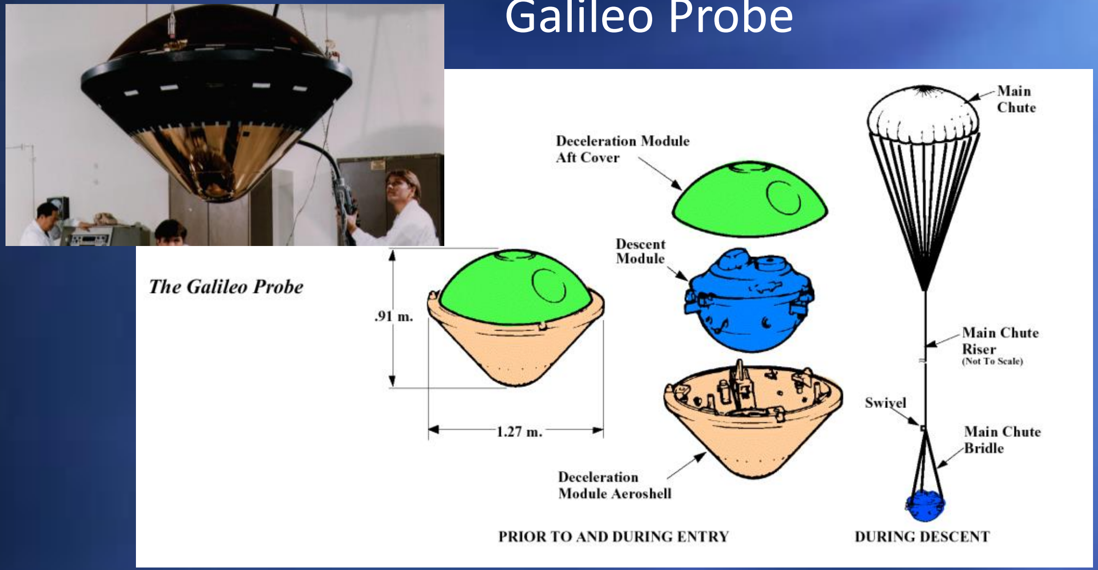


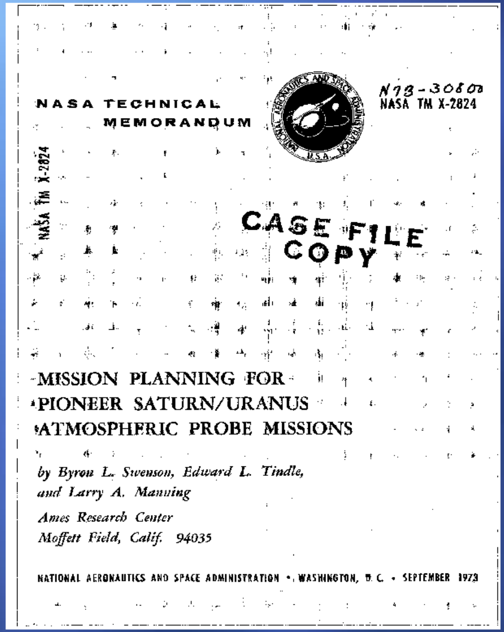




Heritage and Previous Studies

Galileo Probe




NASA TECHNICAL MEMORANDUM

N73-30803
NASA TM X-2824

NASA TM X-2824

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MISSION PLANNING FOR PIONEER SATURN/URANUS ATMOSPHERIC PROBE MISSIONS

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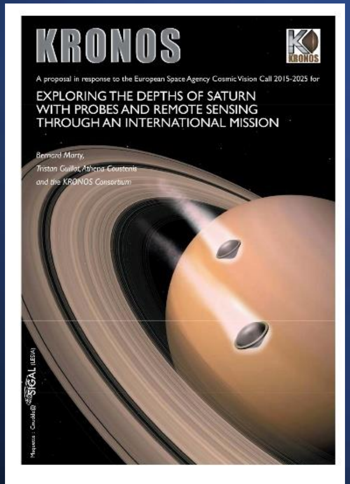
Moffett Field, Calif. 94035

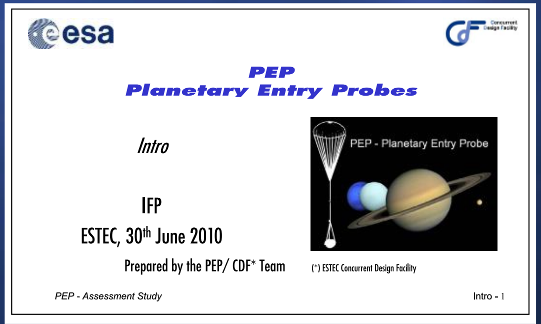
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • SEPTEMBER 1973

NASA 1973

ESA KRONOS Proposal



ESA Huygens Probe



ESA PEP Study


SPRITE
Saturn Probe Interior and Atmosphere Explorer
NASA New Frontiers 4
Amy Simon, PI


Hera
Saturn
Entry Probe
Mission
A Proposal in Response
to the ESA Call for a
Medium-size mission opportunity
in ESA's Science Programme
for launch in 2029-2030 (M5)
Olivier J. Mousis,
David H. Atkinson
and the Hera Team
October 5, 2016
esa
NASA

Saturn Entry Probe Potential

for Uranus and Neptune Missions

Thomas R. Spilker, *Jet Propulsion Laboratory / CIT*
David H. Atkinson, *Univ. of Idaho*

9th International Planetary Probes Workshop
Toulouse, France

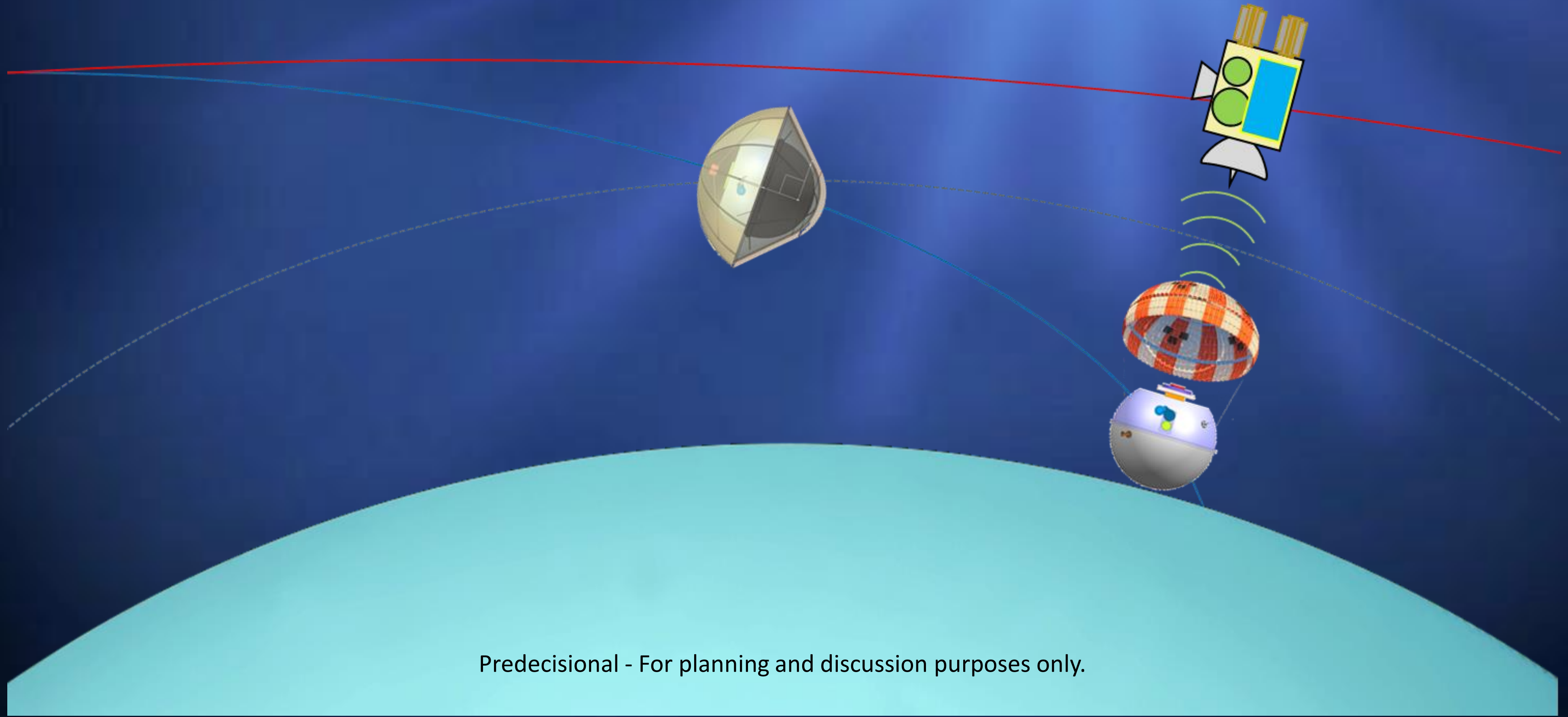
2012 June 18

Ice Giant Probe Mission Concept

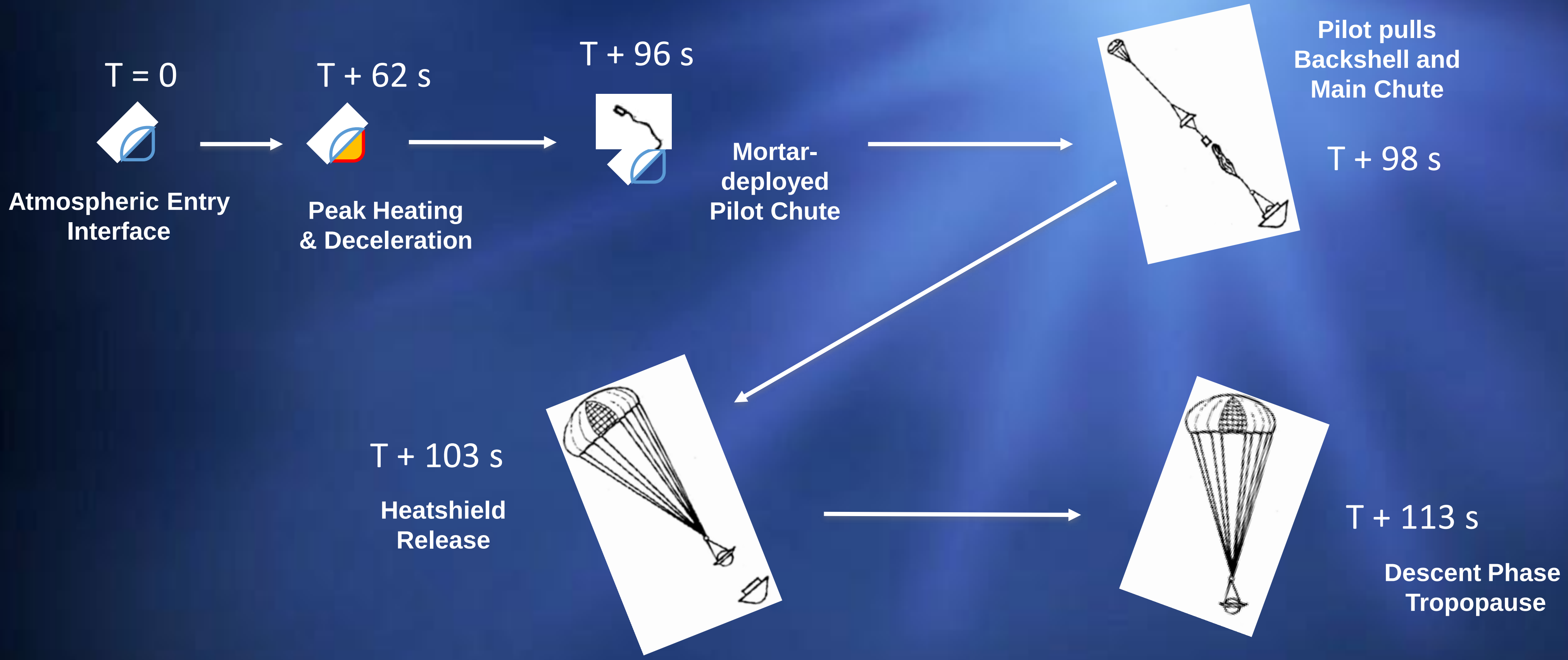
Release:
- 60 days prior to entry
- Spin stabilized
- RHUs for coast heating

Uranus/Neptune Entry
Entry V = 23.5/24.1 km/s
FP Angle = -30/-20 deg

Telecomm to Carrier Relay Spacecraft
Duration: >1 hr
Max Range: <100,000 km

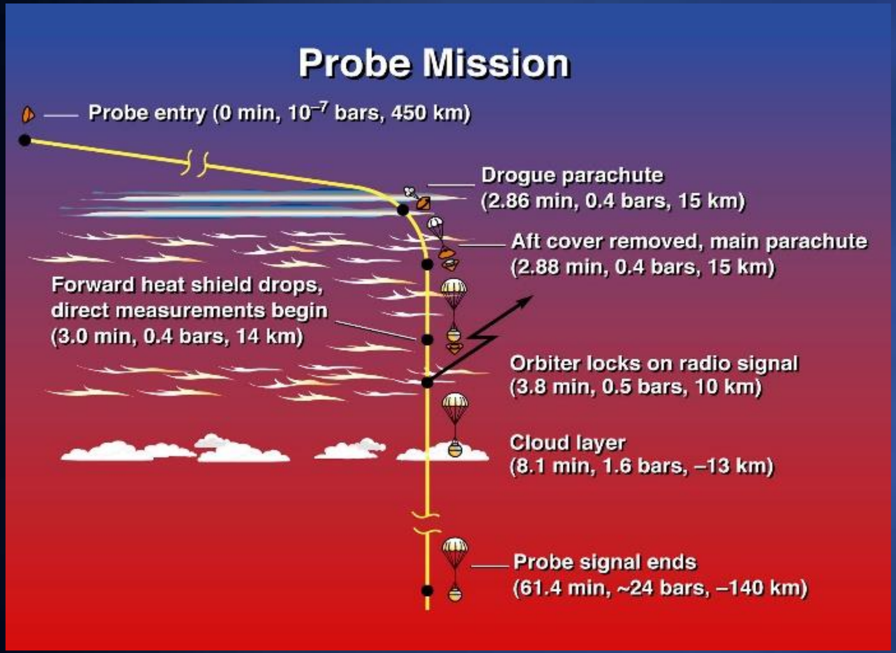


Ice Giant Entry Sequence



Core Mission Profile

HEEET (provided by NASA) would enable significant mass savings over Carbon-Phenolic for range of EFPAs



Galileo entry, descent and deployment sequence provides basis for proposed future Ice Giant missions.

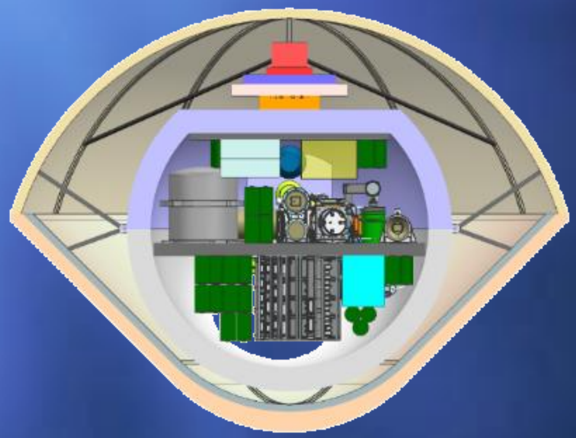
Table E.1 Entry System Mass Estimates

Entry Flight Path Angle (EFPA), degrees	-8		-19	
	Mass, kg			
TPS Material	HEEET	Carbon Phenolic	HEEET	Carbon Phenolic
Entry System (total mass)	215	255	199	223
Deceleration module	92.6	132.6	76.6	100.6
Forebody TPS (HEEET)	40	80	24	48
Afterbody TPS	10.5	10.5	10.5	10.5
Structure	18.3	18.3	18.3	18.3
Parachute	8.2	8.2	8.2	8.2
Separate Hardware	6.9	6.9	6.9	6.9
Harness	4.3	4.3	4.3	4.3
Thermal Control	4.4	4.4	4.4	4.4
Descent Module	122.7	122.7	122.7	122.7
Communication	13	13	13	13
C&DH Subsystem	18.4	18.4	18.4	18.4
Power Subsystem	22[1]	22[1]	22[1]	22[1]
Structure	30	30	30	30
Harness	9.1	9.1	9.1	9.1
Thermal Control	4.3	4.3	4.3	4.3
Science Instrument	25	25	25	25
Separate Hardware	0.9	0.9	0.9	0.9

Note. *Deceleration of (or Entry System) module 1m diameter aeroshell, 36 km/s inertial velocity, 10 deg latitude). The descent module mass estimate, except for the Science Instruments, are the same as that of Galileo Probe. Additional mass savings are likely when the descent system structure is adjusted for reduction in scale as well as entry g-load. Galileo design-to g-load was 350. Saturn probe entry g-load with 3-sigma excursions will be less than 150 g's.*

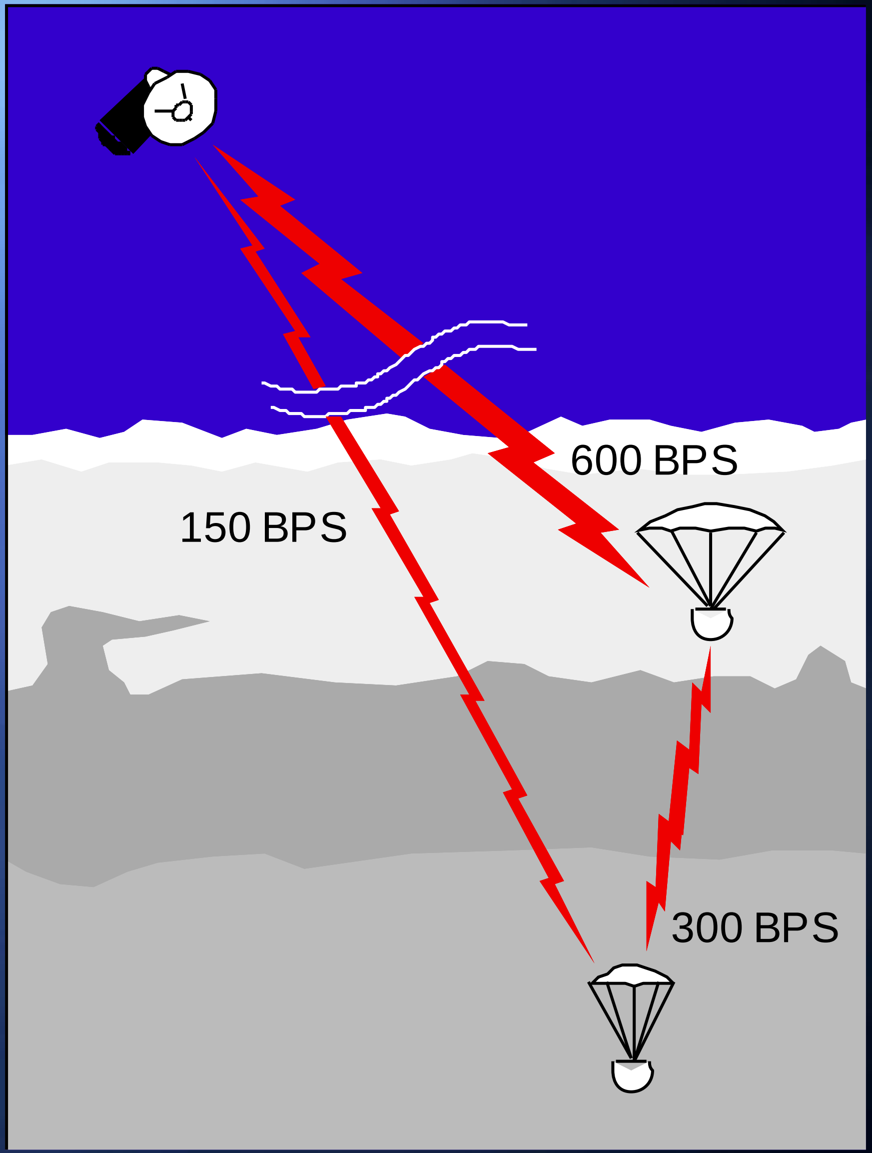
Probe Science Payload

Instrument	Measurement
Mass Spectrometer (MS)	Elemental and chemical composition including noble gases and key isotopes
Atmospheric Structure Instrument (ASI)	Pressure and Temperature, Entry and Descent Accelerations → Density
Radio Science Experiment	Atmospheric dynamics: winds and waves; atmospheric absorption → composition
Nephelometer	Cloud structure, aerosol number densities and characteristics
Net Flux Radiometer	Net radiative fluxes: upwelling thermal IR, solar energy
Helium Abundance Detector	Helium Abundance



Deep Probe Telecommunications: Staged Probes

- Outer planet atmospheres primarily H_2/He but with significant radio-absorbing species: NH_3, H_2O
- At UHF frequencies, shallow probes (10-20 bars) remain within relatively "clear" atmosphere → low opacity
- Communication through deep absorbing atmospheric overhead → greatly reduced data throughput.
- Architecture: Shallow probe descending slowly releases deep probe for rapid descent.
- Telecommunications: Potential to overcome deep RF opacity to limit significantly reduced data rates.

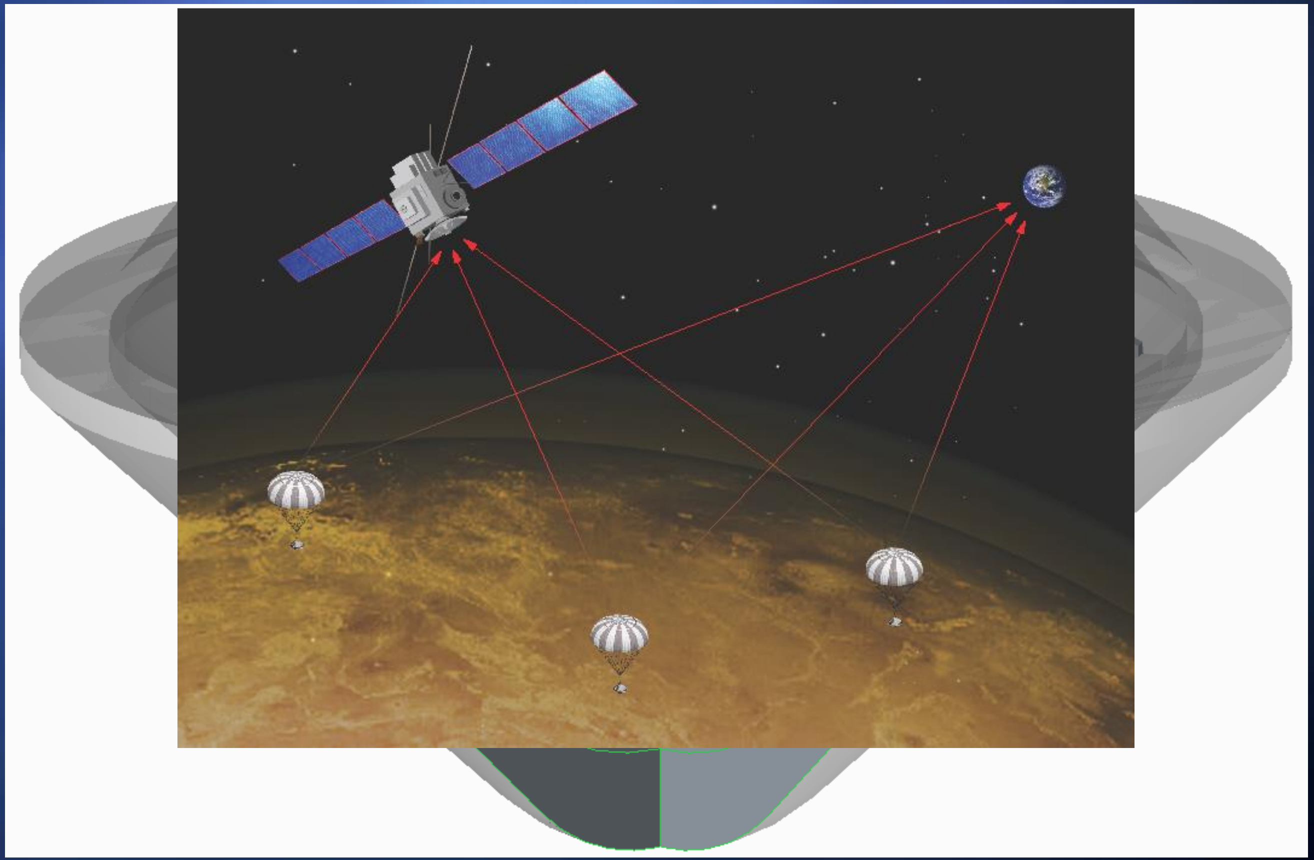


Small Secondary Probes

Secondary probe to complement a primary probe mission to provide in situ measurements of spatially varying atmospheric structure, dynamics, and properties

- Mass: 30 kg, Diameter: 50 cm
- Power: Primary Batteries
- Heatshield: HEEET
- Depth: 5-10 bar

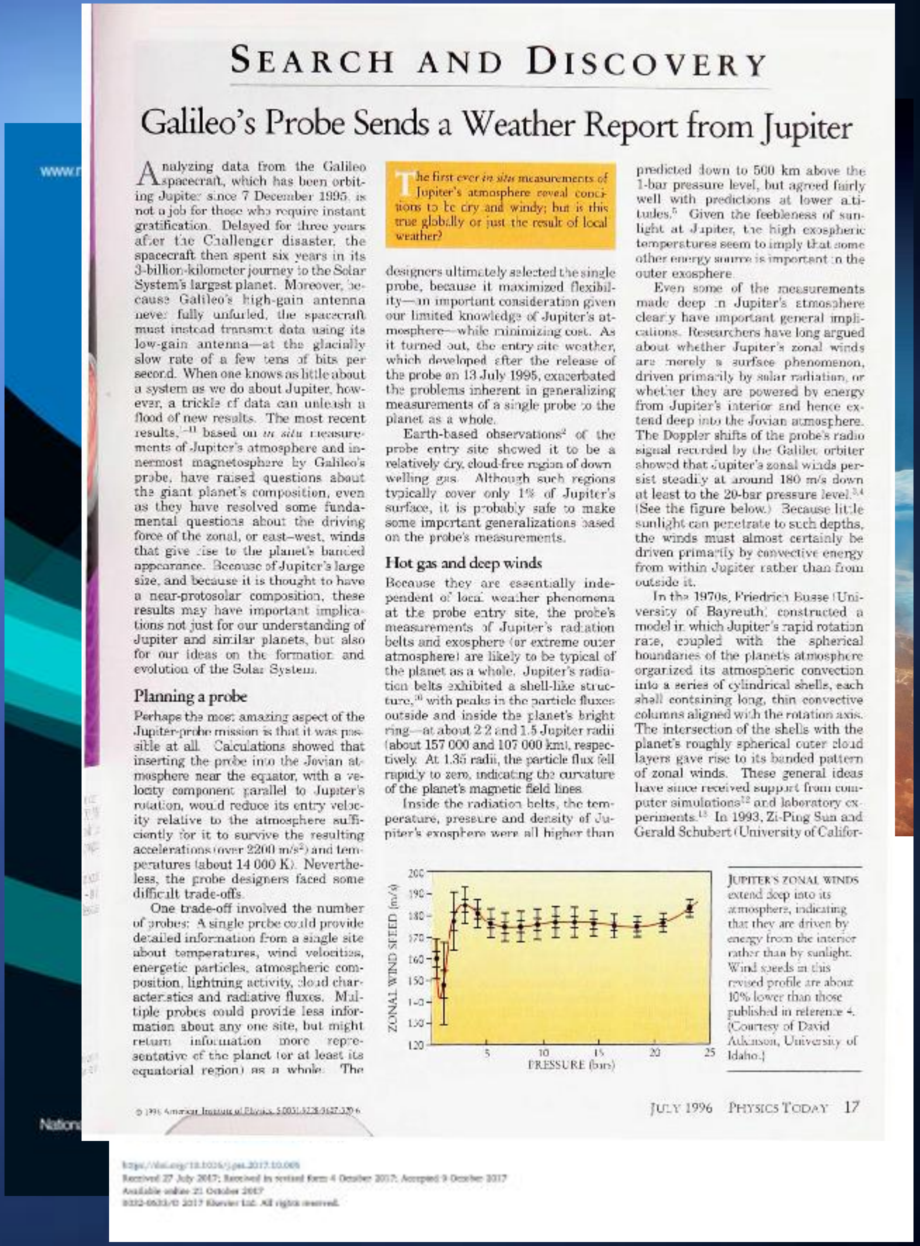
PSDS3 SNAP (Small Next Generation Atmospheric Probe, Sayanagi, et al.) design concept enables future small multiprobe missions, or as a 2ndary probe flying in tandem with a primary probe.



Summary

- The Giant Planets played a significant role in shaping the architecture of the solar system and the evolution of the terrestrial planets.
- With the exception of in situ measurements of Saturn's atmospheric composition, the Jupiter and Saturn systems have been explored in detail. The last largely unexplored class of planets is the Ice Giants.
- Remote Sensing is a very power technique, but is unable to measure essential components of the atmosphere, noble gases and key isotopes in particular.
- The legacy of the highly successful Galileo probe mission directly translates to concepts for future giant planet entry probe missions. Over the past decade, significant effort has been put into developing concepts for Saturn entry probe missions.

Future in situ explorations of the ice giants will draw heavily on the experience of Galileo, and the Saturn probe mission concept studies.



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